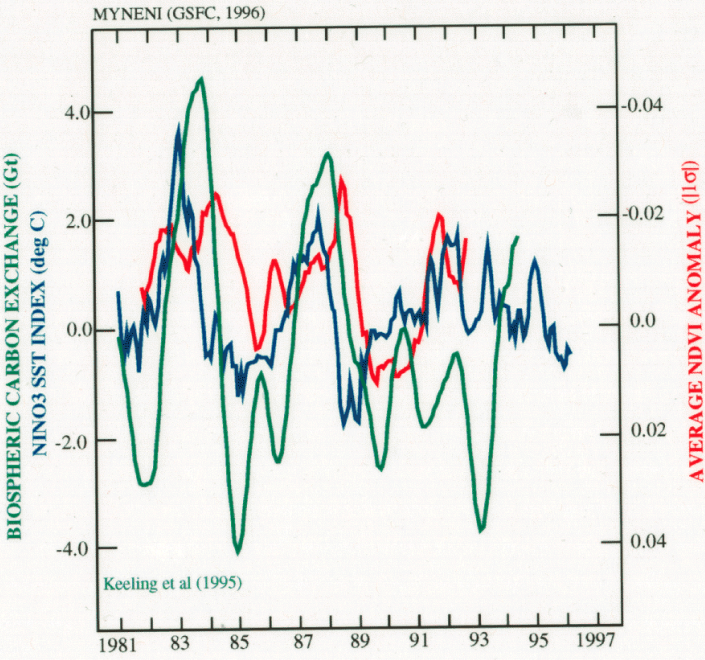

MYNENI (GSFC, 1996)
BIOSPHERIC CARBON EXCHANGE (Gt)
NINO3 SST INDEX (deg C)
AVERAGE NDVI ANOMALY (|1σ|)
4.0
2.0
0.0
-2.0
-4.0
-0.04
-0.02
0.0
0.02
0.04
Keeling et al (1995)
1981
83
85
87
89
91
93
95
1997

RADIATIVE TRANSFER BASED SYNERGISTIC MODIS/MISR ALGORITHM FOR THE ESTIMATION OF GLOBAL LAI & FPAR

RANGA B. MYNENI

GEOGRAPHY/UMD @ CP
BIOSPHERIC SCIENCES BRANCH/GSFC

GOAL

Develop and Implement a RT based Algorithm for

Leaf Area Index (LAI)
Fraction of PAR absorbed by Vegetation (FPAR)

Accuracy: **0.5 LAI & 0.1 FPAR**

Spatial Resolution: **1 km & 1 X 1 degree**

Temporal Frequency: **5 - 7 days & 1 month**

MAIN ALGORITHM

LOOK-UP TABLE METHOD with ancilliary static data layers

- potential MODIS/MISR Synergy
  with MODIS-only flexibility

BACK-UP ALGORITHM

VEGETATION INDEX BASED

Robust (always meets the minimum accuracy)

DEFINITION PHASE **algorithm feasibility**

EXECUTION PHASE **implementation & validation**

diative Transfer in Vegetation Media: A horizontally heterogeneous vegetation canopy of p
Z_C bounded by a flat and anisotropically reflecting soil surface is considered. Specifically, we
:al solution to the following boundary value problem,

$$[\underline{\Omega} \bullet \vec{\nabla} + \sigma(\vec{r}, \underline{\Omega})] I(\vec{r}, \underline{\Omega}) = \int_{4\pi} d\underline{\Omega}' \sigma_s(\vec{r}, \underline{\Omega}' \rightarrow \underline{\Omega}) I(\vec{r}, \underline{\Omega}')$$

$$I(0, \vec{p}, \underline{\Omega}) = I_E \exp\left[-\frac{\tau_A}{|\mu|}\right] \delta(\underline{\Omega} - \underline{\Omega}_o) + I_d(\underline{\Omega}) \ , \quad \mu < 0 \ ,$$

$$I(Z_C, \vec{p}, \underline{\Omega}) = \frac{1}{\pi} \int_{2\pi} d\underline{\Omega}' R_S(\vec{p}, \underline{\Omega}' \rightarrow \underline{\Omega}) |\mu'| I(Z_C, \vec{p}, \underline{\Omega}') \ , \ \mu' < 0 \ , \ \mu > 0 \ ,$$

- discrete ordinates method

quadrature in angle
finite difference scheme for spatial derivative
solution by iteration on the scattering integral & its acceleration

- allows proper boundary conditions

- vertical & lateral heterogeneity

- includes hot spot effect & specular reflection from leaves

- mutual shadowing between crowns

- validated

benchmark solutions
crop canopies
grasslands
shrublands
broadleaf and needle forests

JQSRT, 1988; TTSP, 1990, JQSRT, 1993; IEEE TGARS 1996?

Given:

surface spectral bidirectional reflectances

calibrated
atmosphere-corrected

Known:

illumination & viewing geometry
spectral bandwidths & instrument response functions

estimate LAI & FPAR

ANCILLIARY DATA LAYERS

BIOME TYPE

leaf optical properties & some structural variables

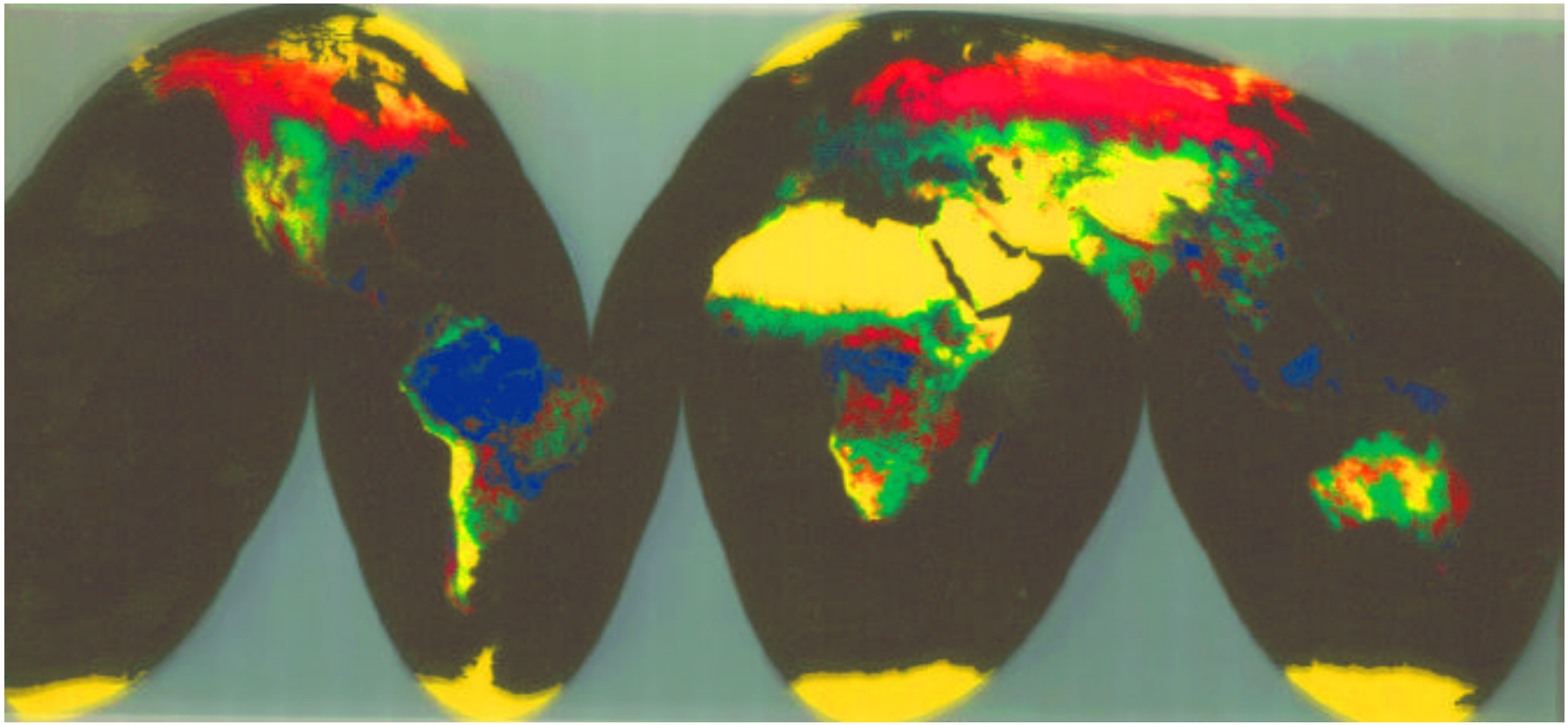
GROUND COVER

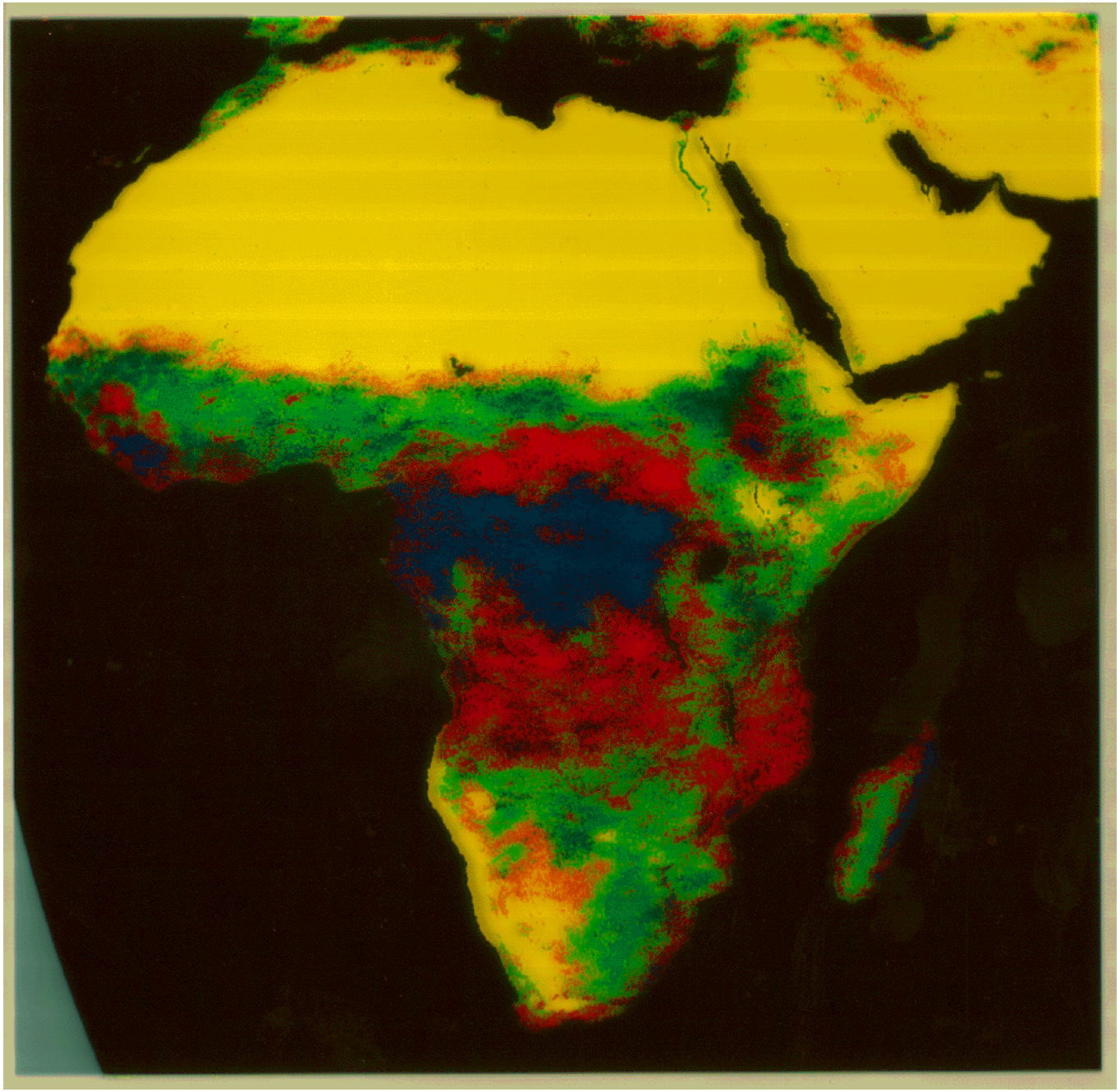
SOIL REFLECTANCE

(directional-hemispherical spectral reflectance)

GLOBAL BIOME CLASSIFICATION CAMPATIBLE WITH RADIATIVE TRANSFER

	Biome 1 **Grasses & Cereal Crops**	Biome 2 **Shrubs**	Biome 3 **Broadleaf Crops**	Biome 4 **Savanna**	Biome 5 **Broadleaf Forests**	Biome **Needle Forest**
Horizontal Heterogeneity (ground cover)	no	low	variable	low (o/s)	yes	yes
Vertical Heterogeneity (leaf optics & LAD)	no	no	no	yes	yes	yes
Stems/Trunks	no	no	no	o/s	yes	yes
Understorey	no	no	no	biome 1	yes	yes
Foliage Dispersion	minimal clumping	random	regular	minimal clumping (u/s)	clumping	severe clumpin
Needle Clumping on Shoots	no	no	no	no	no	yes
Crown Shadowing	no	yes	no	no	yes	yes
Background Type	medium	bright	dark	medium	dark	dark





VEGETATION INDEX BASED

- simple
- robust
- biome specific
- sun angle specific
- background specific

Figure 5a (Private Communication from Running, 1995)

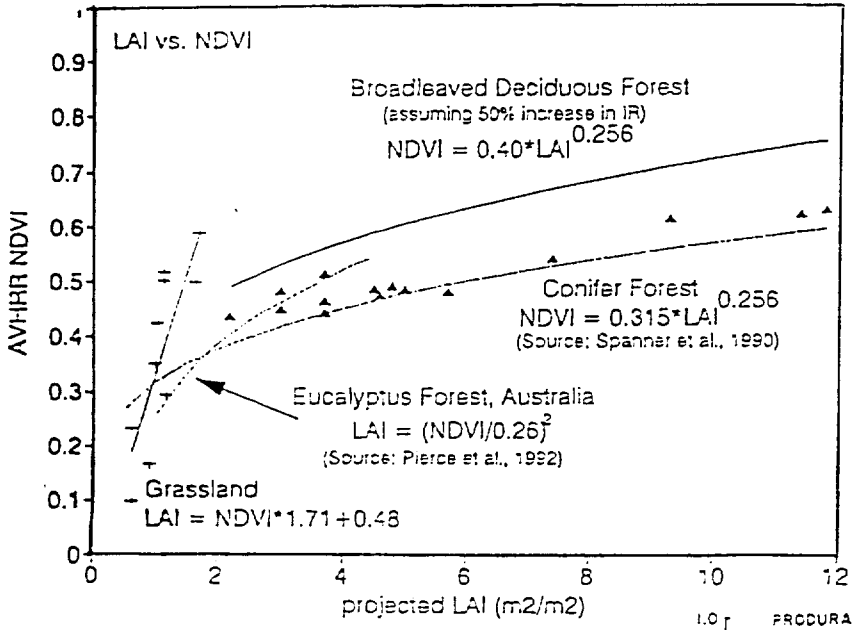
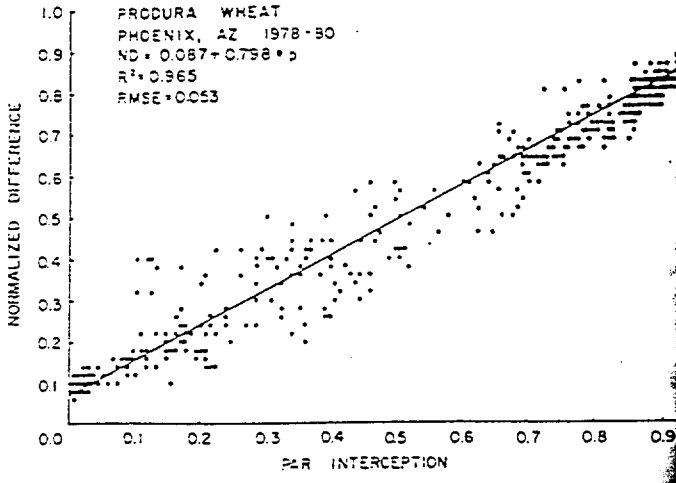


Figure 5b (Asrar et al., 1984)



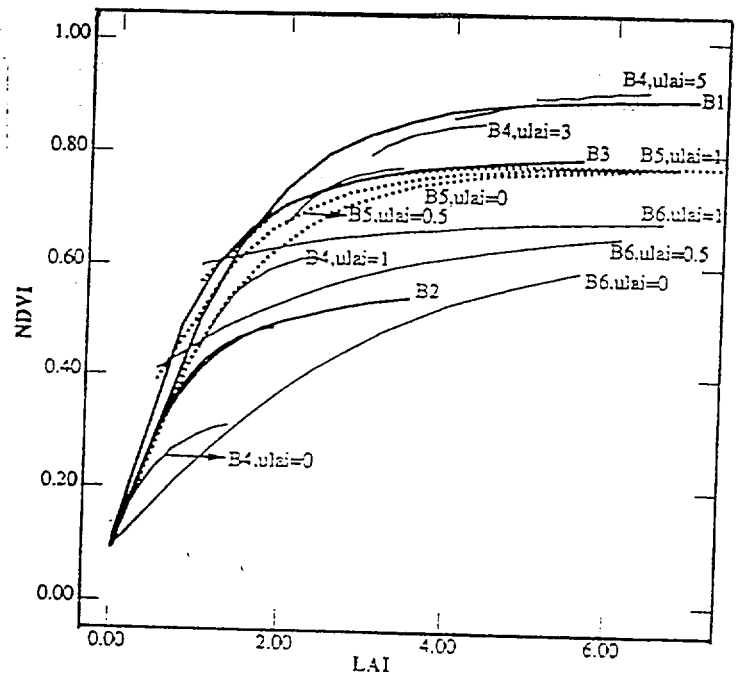


Figure 8a
(Bn : Biome n, n = 1, 2, ..., 6)
(ulai : understory LAI)

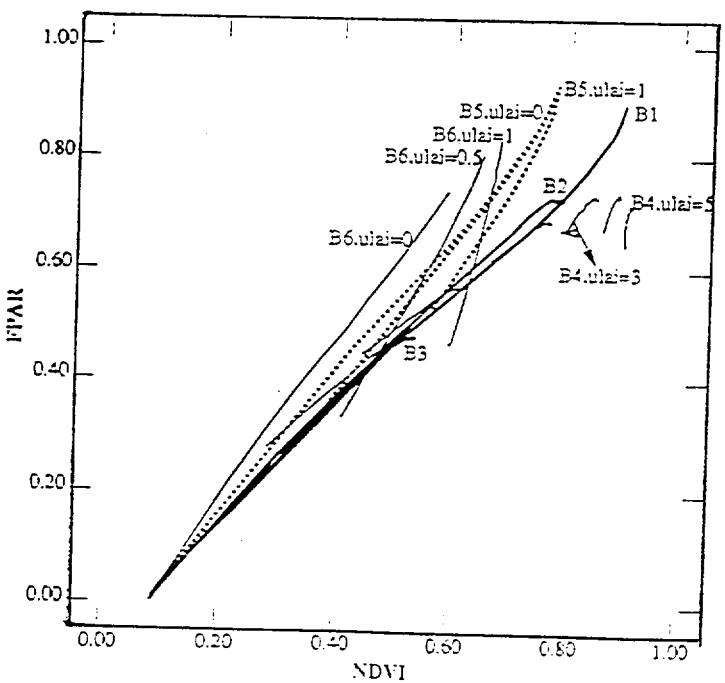
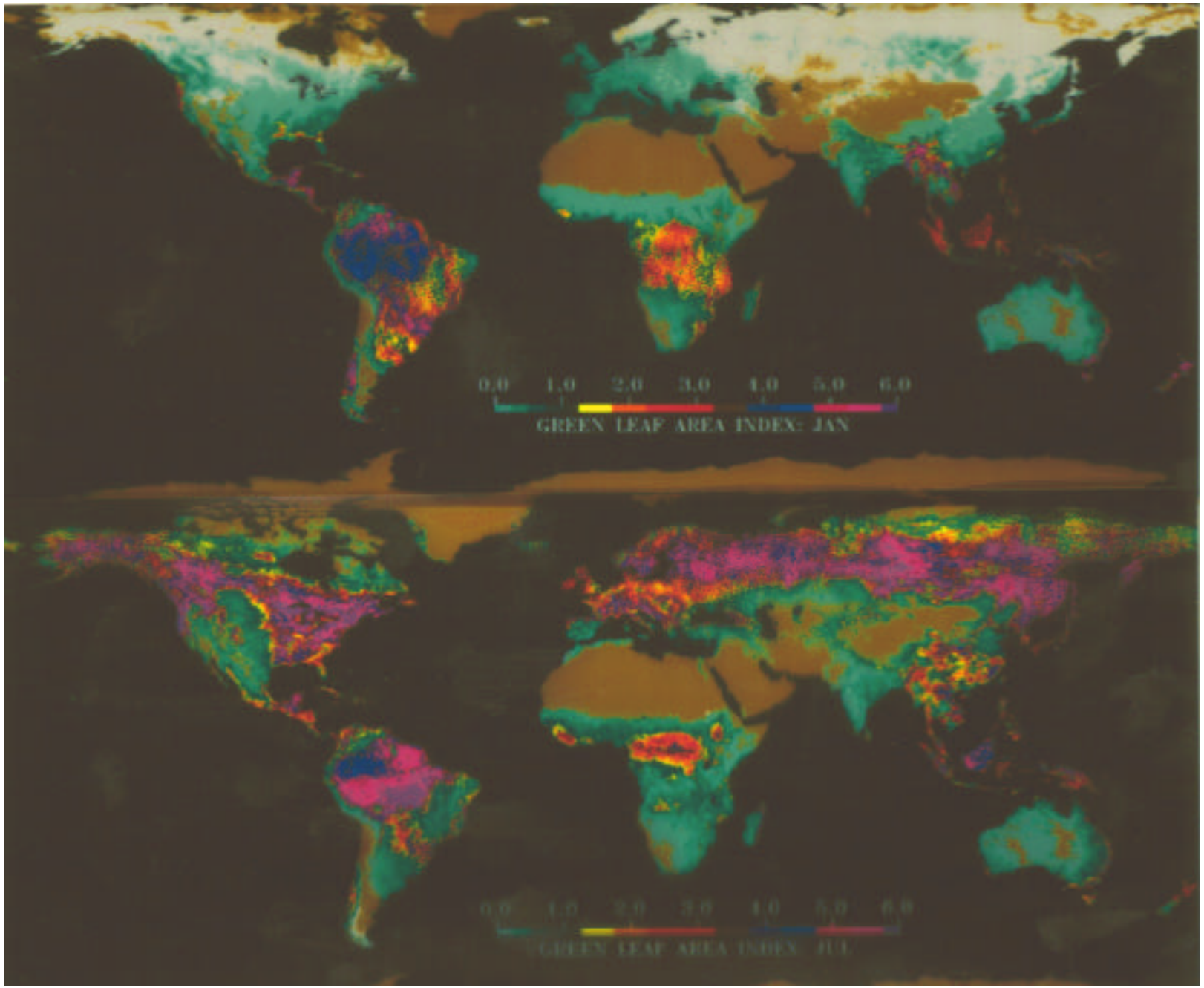


Figure 8b
(Bn : Biome n, n = 1, 2, ..., 6)
(ulai : understory LAI)


0.0 1.0 2.0 3.0 4.0 5.0 6.0
GREEN LEAF AREA INDEX: JAN
0.0 1.0 2.0 3.0 4.0 5.0 6.0
GREEN LEAF AREA INDEX: JUL

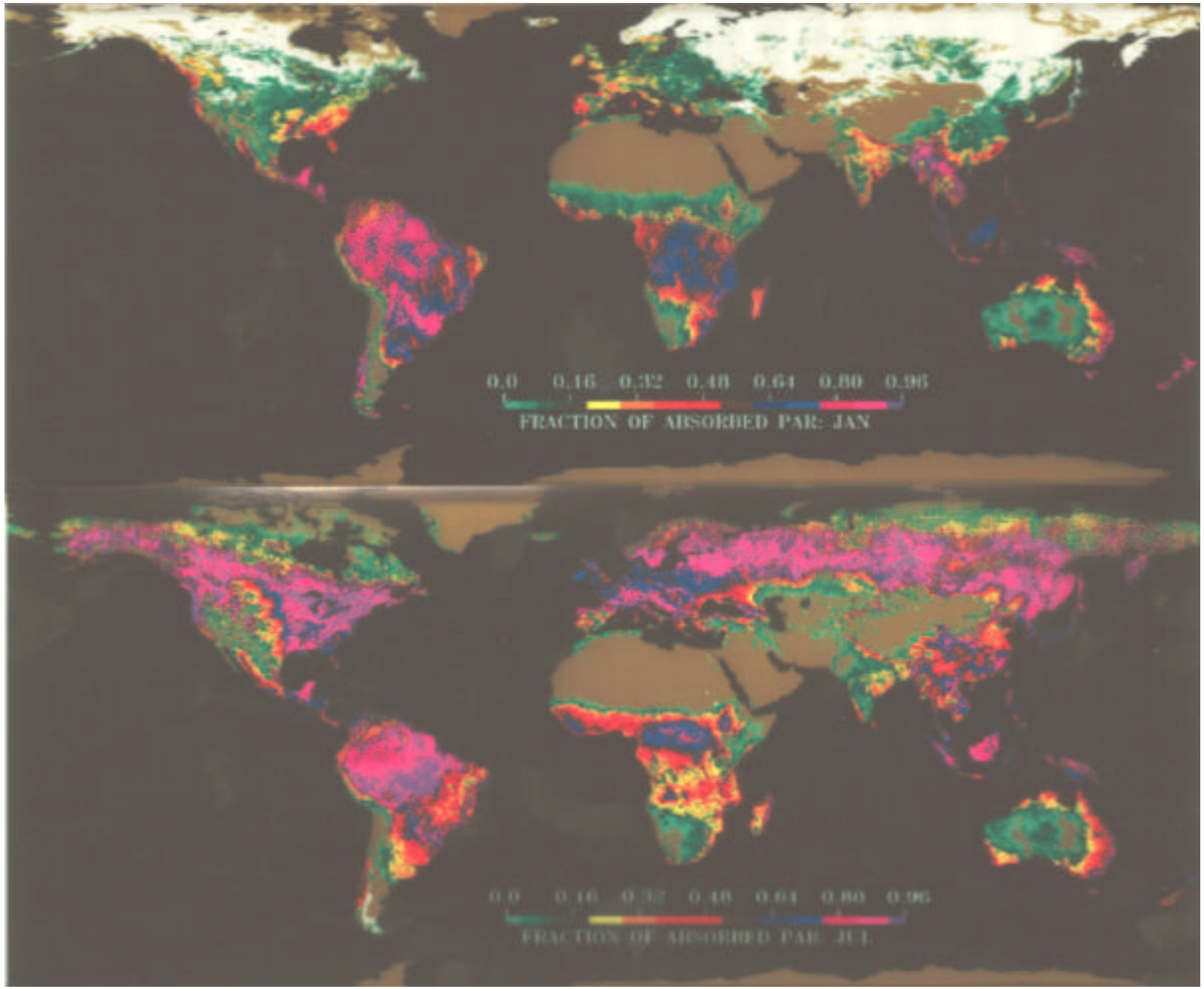
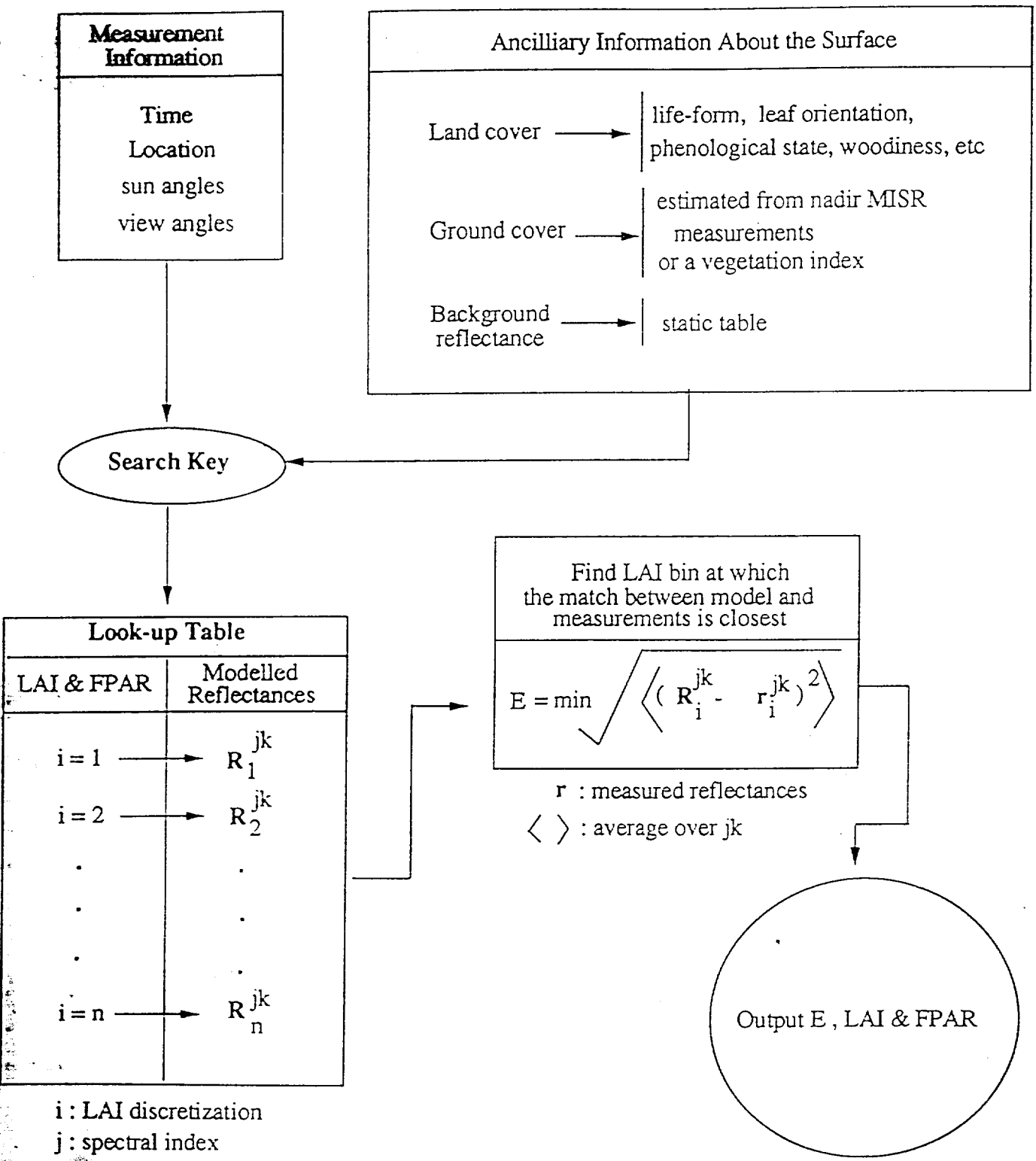
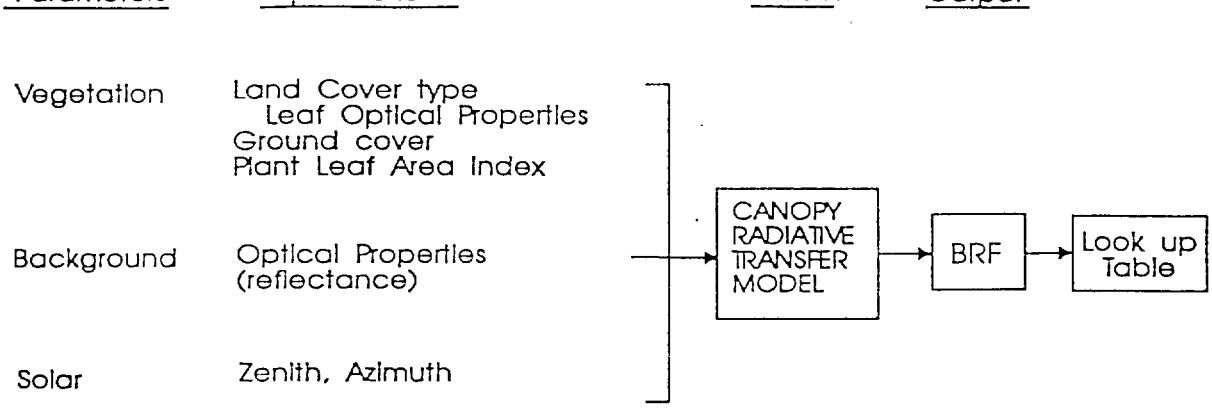

0.0 0.16 0.32 0.48 0.64 0.80 0.96
FRACTION OF ABSORBED PAR: JAN
0.0 0.16 0.32 0.48 0.64 0.80 0.96
FRACTION OF ABSORBED PAR: JUL

Figure 12

Look-up Table Based Approach to LAI & FPAR Estimation From Remote Observations



MODELING OF REMOTE SENSING OBSERVATIONS



Land Cover: Broad leaf, Needle leaf, Grass
Leaf Optical Properties: Reflectance, Transmittance
Ground Cover: Range:10-100, Interval: 10%
Plant LAI: Range: 1-10, Interval: 2
Background: dark (clay, organic, litter), Bright (sand, oxidized soils)
Zenith: Range: 0-90, Interval: 10
Azimuth: Range: 0-180, Interval: 20

Radiative Transfer model of Myneni et al.1992
BRF Bi-directional Reflectance Factor
VI Vegetation Index
FPAR Fraction of Absorbed PAR

- back-up & main algorithms
- reflectance based main algorithm
- utilizing spectral and angular variance
- improved land cover classification
- characterization of ground cover
- tie-in with MISR
- physically based method with some estimate of accuracy/error

SCHEDULE OF ACTIVITIES

Version 1 Coding & delivery on schedule (June 1996) **UMT**

Continued RT model development & validation **UMD**

LOOK-UP TABLE research issues **UMD**

- grid interval
- testing at smaller spatial scale (FIFE, BOREAS ...)

Version 2 (mid 1997)

1 KM BIOME TYPE CHARACTERIZATION — UMT/UMD

Demonstrating the feasibility of the Algorithms by developing Prototype LAI/FPAR data sets from AVHRR Land Pathfinder 1 data **UMT/UMD**

MODIS/MISR Synergy Issues **UMD**

Improved Biome Type Characterization for LAI/FPAR Estimation **UMT/UMD**

→ Post-Launch

ALGORITHM IMPLEMENTATION

INTERACTIONS WITH SDST

FIELD STUDIES (Parameterization)

VALIDATION ACTIVITIES (Instrument Team) **UMT**

UMD

THEORY
ALGORITHM DEVELOPMENT
(scientific coding; delivery to UMT)

MODIS/MISR INTEGRATION
SENSITIVITY & ERROR ANALYSIS
I. T. Validation Activities